GRASP Patterns (Ch. 18)

- Responsibility:
  - "A contract or obligation of a type or class"
- Two type of responsibilities
  - knowing
    - about private encapsulated data
    - things that can derive or calculate
  - doing
    - something itself
    - initiating action in other objects

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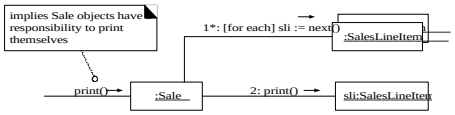
Responsibilities & Interactions

- Methods Implement Responsibilities



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Patterns

- Named "problem/solution" pairs
- Primitive examples from OOP:
  - Model - View - Controller (MVC)
  - Object - Attribute - Value (OAV)
- GRASP (Larman)
- Gang of Four (GoF; Gamma, et. al.)

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Basic GRASP Patterns

- Expert
- Creator
- Controller
- High Cohesion
- Low Coupling
- Learn the other patterns after these are mastered

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Expert Pattern

- The most commonly used pattern
- Assign a responsibility to the information expert
  - the class that has the information necessary to fulfill the responsibility
- Example:
  - In POST, who should know the grand total of a sale?

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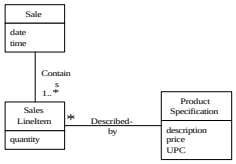
Grand Total Expert?



- Who knows about *SalesLineItem*s and their totals?

Answer: *Sale*

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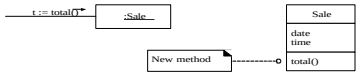
What Else is Needed?



- What constitutes the line item subtotal?
  - `SalesLineItem.quantity`
  - `ProductSpecification.price`
- Who is the expert on both of these?
  - Answer: *SalesLineItem*
- *Sale* needs to see subtotal msgs from *SalesLineItem*

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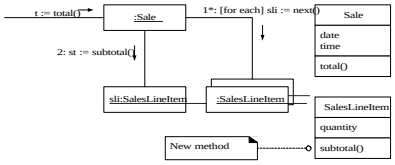
Resulting Collaboration Diagram



- *Sale* needs to send subtotal msgs to each *SalesLineItem* and sum the results
- In turn, *SalesLineItem* must send a *price* msg to *ProductSpecification*

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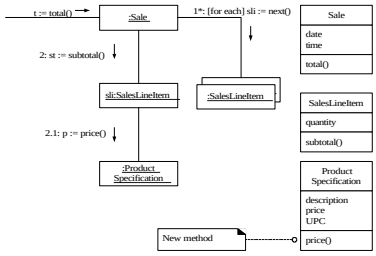
Resulting Design



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Expert - Conclusions

- In the real world, items don't tell you their price; line items don't tell you their total
  - But in O-O world, they do!
  - This principle is called "Animation" or the "Do it Myself" principle
- Also works in the workplace (real world)
  - Who puts together the profit/loss statement?
  - Ans: the person in accounting with all the data

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Creator Pattern

- Assign class B the responsibility to create an instance of class A if one of the following is true:
  - B aggregates A-type objects (collects)
  - B contains A-type objects (owns)
  - B records instances of A-type objects
  - B closely uses A-type objects
  - B is an expert w/r/t creating A-type objects
    - B has the initializing data that will be passed to A when it is created
- In all cases, B is the creator of A-type objects!

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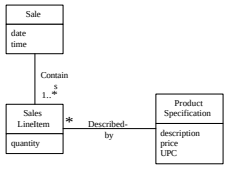
Who Should Create SalesLineItem Instances?



- Answer: *Sale* - since it aggregates many *SalesLineItem* instances
- Requires a *makeLineItem* method be defined in *Sale*

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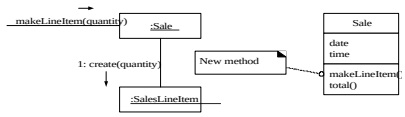
Resulting Design



- Question: Who would best be able to create a Payment object?
  - Answer: *Sale* - since it aggregates necessary data (like total sale) to generate the object.

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Low Coupling Pattern

- Formalized by Constantine & Yourdon
  - *Structured Design, 1974*
- *Coupling* is the degree to which modules (separate functions or methods) are inter-related.
- Low coupling is desired
- Levels of coupling are identified

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Levels of Coupling / Cohesion

Best

- Data - Low
- Stamp
- Control
- Common
- Content - High

- Informational - High
- Functional
- Sequential
- Communication
- Temporal
- Logical
- Coincidental - Low

Worst

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Data Coupling

- The lowest level of coupling (the best form)
- Also, the most common form of coupling
- Passing parameters between modules as data
- The fewer parameters passed, the lower the coupling
- Return values are used as data in the caller

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Stamp Coupling

- Selected global variables are shared by multiple modules or routines
- If unexpected values arise in these globals, who is responsible?!
  - Requires a “watch” feature of a symbolic debugger to get a handle on who’s responsible
- Use of global variables is discouraged when parameter passing would suffice

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Control Coupling

- Involves passing of control flags (either through parameters or global variables) as data between modules.
- The return value of the function determines the flow of control in the calling module
  - `if (func()) then … else …`
- What if there’s an error in `func()`?!

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Common Coupling

- Modules are dependent on one anther (bound together) by global data blocks
- Fortran common blocks are the reason for this level of coupling
  - Common blocks are blocks of shared memory, with every holder of the common stmt having read/write access to anything in the block
  - Large amounts of data are typically shared, often to usurp parameter passing of arrays.

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Content Coupling

- The highest form of coupling (worst form)
- Occurs when one module modifies code and/or data in another module
- Some re-enterant code from assembly lang. exhibit this form of coupling
- Can be nearly impossible to detect and debug (because it disappears!)

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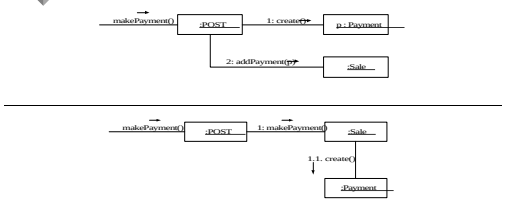
Consider Two Designs



- Which has lower coupling?
  - Answer: The 2nd design

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High Cohesion Pattern

- Formalized by Constantine & Yourdon
  - *Structured Design, 1974*
- Cohesion is the degree to which statements within a module (functions or methods) are inter-related
- The higher the cohesion, the better
- Levels of cohesion are identified

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Levels of Coupling / Cohesion

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- Coincidental - Low

Worst

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Informational Cohesion

- A concrete realization of Data Abstraction
  - classes in C++/Java/other OO langs.
- The module contains data structure(s) and algorithm(s) which are implemented to provide one concept
  - Also known as Abstract Data Types, Packages (Ada), Envelopes (Pascal Plus), Clusters (CLU)
- Everything works together to provide the abstraction

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Functional Cohesion

- Elements within a module are related in performing some mathematical-type function
  - `sin(x)`, `sqrt(x)`, `pow(x, y)`, etc.
- Functional dependence within a module is a common, sought-after feature

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Sequential Cohesion

- Elements are grouped together (in the design of the system) based on data flow
  - Data flow is considered a stronger design issue than control flow!
- Occurs when the output from one element is input to the next element
  - Examples:
    - Read next transaction, update master file
    - "pipes" in Unix, network "sockets"

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Communication Cohesion

- Elements refer to the same set of input or output data at the same time in processing
- Stack operations exhibit this form of cohesion
  - `push()`, `pop()`, `top()`, `new()`, `empty()`
- Data access is also coordinated in time

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Temporal Cohesion

- Group elements together that can all be performed at the same time
- Initializing variables, initializing the state of an object
- Temporally cohesive elements tend to also be logically cohesive

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Logical Cohesion

- Elements are grouped together because they perform the same logical type of operation
- Intializing all variables
  - also temporally cohesive
- Perform all I/O operations
- Process all records from a file
- Display error messages

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Coincidental Cohesion

- The lowest form of cohesion (worst)
- Elements within a module have no apparent relationship!
- Sometimes results when one is forced to upgrade a program to a new language
  - "Modularize" an assembly program Into C
  - Convert a functional program to an O-O language (like Java, which only allows member function, no global functions)

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Coupling & Cohesion

- Are inversely related
  - as one increases, the other decreases
  - Low coupling, high cohesion is good
  - High coupling, low cohesion is bad
- Low cohesion means the module should delegate its work to subclasses
  - Just like the person who takes on too much in life, things become complicated & nothing is done well!

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Controller Expert

- Assign responsibility of handling system events to a class representing:
  - the overall system (*Facade controller*)
  - the overall business or organization (*Facade controller*)
  - something in the real world that is actively involved in the task (like a person playing a role) (*Role controller*)
  - an artificial handler of all system events of a use case, usually named "<UseCaseName>Handler" (*Use Case controller*)
- System events are generated by external actors

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Controller Objects

- A *controller* is a non-user interface object responsible for handling a system event.
- A *controller* defines the method for the *System* object
- POST system events & their operations:

System
endSale() enterItem() makePayment()

System operations do not have to be fulfilled in the System class. During design, controller classes are often delegated the responsibility for system operations

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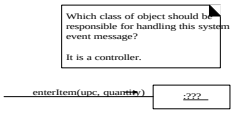
Who Should be the Controller?



- POST
  - represents the overall "system"
- Store
  - represents the business organization
- Cashier
  - represents actor that plays a role in the task
- BuyItemsHandler
  - represents the handler of the system operation in the use case

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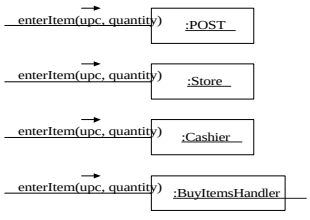
Controller Choices



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Answer: It Depends!

- The same controller should be used for the system events of one use case
  - For instance, *makePayment()* comes after *endSale()*
- Facade controllers are suitable when there are only a few system events.
- Only the role controller should be avoided
  - Bloated controllers; poor Design
- Presentation layer does not handle system events

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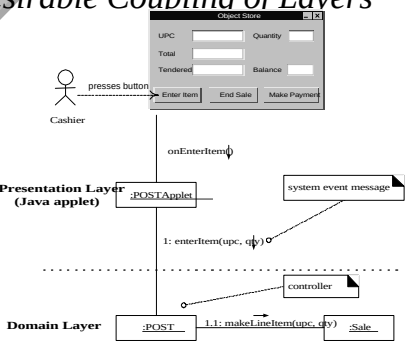
Desirable Coupling of Layers



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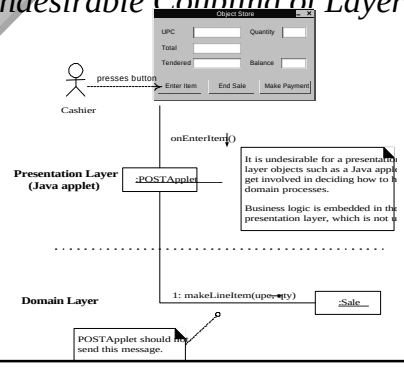
Undesirable Coupling of Layers



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Command Pattern

- Useful when msgs are received, not through a UI, but from a msg handling system
  - Telecommunications switching systems
  - CORBA (object DB) architectures
  - other protocol handlers (mail, ftp, etc.)
- Each command (msg) has its own class
  - each with an *execute()* msg
  - polymorphism allows different subclasses to implement the execution

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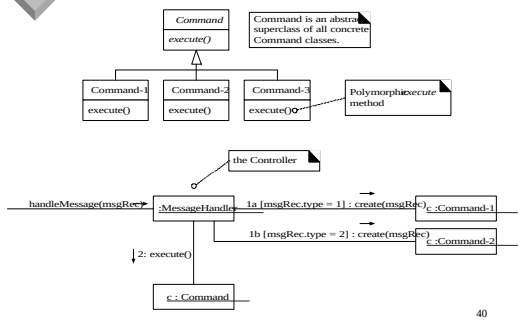
Command Controller Pattern



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Related Patterns

- Command - In a msg handling system, each msg may be represented and handled by a separate Command object
- Facade - Choosing an object representing the entire system or business organization
- Forwarder-Receiver - A Siemens pattern useful for message handling systems
- Layers - Another Siemens pattern. No domain logic in the presentation layer is part of this
- Pure Fabrication - A GRASP pattern. A use case controller is a kind of Pure Fabrication

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CRC Cards *(Beck & Cunningham, 1989)*

- Class, Responsibility, Collaboration Cards
- Each card has a Class name & list of responsibilities
- Each person holds onto cards and "plays the role" of that class in collaborating to perform a task or implement a use case.
- Collaboration and Class diagrams capture the dynamics that occur in the role playing

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